64 different earth stations. In its application (page 77), Teledesic states that co-frequency interference is controlled by low sidelobe levels and the exploitation of alternate polarizations. Unfortunately, while Teledesic had counted on alternate polarizations to suppress co-frequency interference, the NRMC's Joint Technical Sub-Group found that "circularly polarized antennas generally do not maintain a good axial ratio beyond the first major side lobe" and recommended that "no polarization discrimination be considered" into the sidelobes of circular antennas. (NRMC document JTSG 4.3). M/A-COM, Inc. has assessed this issue in detail and its review of the Teledesic self-interference problem is provided as Attachment B. There will typically be about 12 interfering, co-frequency Teledesic signals within thirty degrees of boresight of the antenna for the desired Teledesic signal. Without even considering the other 51 self-interfering signals, this would appear to degrade the carrier-to-interference ratio below the value required by Teledesic. Thus, without polarization isolation, the capacity of the system may be reduced well below Teledesic's *stated* 2 million simultaneous 16 kb/s service links or 20,000 simultaneous T1 service links.

Teledesic Phased-Array Antennas -- Well Beyond Affordable Technology

Aside from the concerns about capacity degradation due to Teledesic self-interference, the likelihood that Teledesic can produce the earth station antennas required for system operation is low, and any such antennas are likely to be prohibitively expensive relative to data communications alternatives available to would-be Teledesic subscribers. Teledesic's design tolerances for its earth station phased-array antennas, as described on page A2 of its technical paper attached to its December 2, 1994 Supplemental Comments, imply that the production yields on the final product will be fairly low, driving up the cost of the antenna. This is due to the design goal of holding phase error in the array to less than five degrees. This specification is well beyond anything envisioned for production in the 28 GHz band, and costs will be driven up further by the fact that Teledesic plans a "family" of different antenna sizes for various terminal data rates. Thus, production runs of a given type will be smaller than if a single antenna type was used across the Teledesic system. While Teledesic is elusive about the details of this "miracle" antenna, the cost impact of such tolerances is severe whether Teledesic intends to use a single dual-band (uplink and downlink) array for the earth terminal or whether separate, single-band arrays are planned. Regardless of the approach attempted, the phase tolerances, even if achieved in hardware, would be rendered inadequate if any rain, dust, bird droppings, etc. light on the horizontal surface of the antenna, disturbing its far-field characteristics. Note that Teledesic, unlike LMDS, must operate its phased-array antennas with a physical orientation in the plane of the earth surface since they will not be able to maintain their gain and sidelobe characteristics over scan limits more than a few tens of degrees from the perpendicular to the surface of the antenna. Teledesic admits this when it states "improvement for scan angles of 50 degrees from the axis is not possible...(and) no improvement beyond that proposed by Teledesic is possible." (Teledesic paper attached to December 2, 1994 Supplemental Comments). This statement further implies that Teledesic has found the "holy grail" in antennas--since nobody, according to Teledesic, could possibly improve upon Teledesic's design. Operating at such limits is sure to be expensive--if not technically impossible.

Design Alternatives for Broadband Satellite Service

Beyond the issues of sidelobe suppression, shielding, capacity and terminal cost are many other technical design elements of the Teledesic system which, while not arbitrary, are likewise not selected with practicality and sharing criteria in mind. Teledesic's system design, as defined in its Application to the Commission and reiterated in a document entitled "Characteristics of Teledesic's Ka Band, Low Earth Orbit, FSS Network to Provide Global Voice, Data, and Video Communications" (entered into the Negotiated Rulemaking Committee record as document number NRMC-24), is only one of many possibilities for broadband satellite service. In fact, there are numerous design changes which, if implemented, would greatly reduce the potential interference between Teledesic terminals and LMDS without impact on Teledesic performance. These include a modification of the multiple access scheme to accommodate broadband CDMA or other code spreading of uplink signals to reduce the power spectral density of the uplink transmitter signal, or the use of TDMA on the uplink which would reduce the duty cycle of a given earth station terminal. These change are achievable within the signal processing complexity and system framework envisioned by Teledesic, and yet no potential changes have been offered. In fact, Teledesic refused, in the NRMC work period, to give reasonable consideration to a frequency assignment scheme, suggested by CVNY, that would accommodate reasonable levels of band sharing--without significant system design changes--that would ultimately benefit both Teledesic and LMDS proponents.

Teledesic Economic Feasibility and Practicality--A View from a Technical Perspective

Teledesic states in its paper attached to its Supplemental Comments (December 2, 1994) that " antenna patterns....are neither achievable nor economically feasible." (page 1). As has been addressed above, sidelobe suppression improvements of the magnitude contemplated by BellCore and others weighing interference mitigation and sharing issues are within the bounds of *current* technology. However, since achieveability and economic feasibility apparently an issue from the viewpoint of Teledesic, it is interesting to consider the Teledesic concept and application. In doing this, extreme doubt is cast upon the entire Teledesic scheme. A few examples are in order.

First, it should be noted that nowhere in its application to the Commission did Teledesic address the design or cost of the ground segment of its network. Given the complexity of the phased-array antennas Teledesic envisions for the earth stations, an extremely conservative estimate of the cost of a Teledesic terminal capable of multiple transmission rates and utilizing a steerable antenna of the design complexity and tolerance described in Teledesic's paper (page A2) attached to the Supplemental Comments (December 2, 1994) is approximately $3,000. This is, in fact, extremely conservative since to construct such an antenna today would probably cost of the order of 10 to 100 times this amount. Given this estimate, $3,000 per terminal, and Teledesic's assertion that 20 million such terminals are likely, the total capital cost of the Teledesic system would be the sum of the terminal costs ($60 billion) and the cost of the satellite constellation (conservatively estimated by Teledesic in their application to the Commission at about $9 billion) for a total system cost of $69 billion, which does not include to cost of replacement of inoperable system elements, operations, or payments for landing rights to telecommunications carriers indigenous to countries of operation.

The 69 Billion Dollar Question

What does this minimum of $69 billion buy? It buys a system for which the capacity available world-wide is *only* two million simultaneous 16 kb/s access lines or twenty thousand simultaneous T1 lines. This is roughly equivalent to fifty OC-4 fiber optic transmissions, or less than what one might expect as traffic in and out of a *single* major American metropolitan area. As a result of the low, but probably still unrealizable system capacity claimed by Teledesic, after ten years of operations (sixteen years from now), according to Teledesic's own revenue estimates. Teledesic *still* will not have collected enough revenue to repay the *initial* capital cost of the Teledesic system. In reality, the capacity of the Teledesic system, due to implementation difficulties, is likely significantly below that projected by Teledesic--this would reduce revenue and further increase the payback period for system infrastructure. Furthermore, after ten years of operations, by Teledesic's own estimate approximately 30 percent of the satellites in the constellation will have failed, forcing expensive development, launch and orbital insertion of replacement satellites. By any measure, the financial risk of the Teledesic system is enormous. Perhaps this, in part, explains why Teledesic's wealthy principals, Bill Gates and Craig McCaw, according to the Teledesic application, have committed only 0.11 percent of the total capital needed to establish the satellite constellation and only 0.0145 percent of the total projected cost of the system using the estimates above. This level of investment does not convey much confidence in the Teledesic technology. Noteworthy experts including John Pike, Director of the American Federation of Scientists' Space Policy Project, and Howard Anderson, of the Yankee Group, have said of the Teledesic plan: "It's the stupidest damn thing I ever heard of;" and "The system ain't gonna work."

Teledesic Capacity is a Trivial Fraction of LMDS Capacity

It is interesting to compare the capacity of LMDS, as a measure of its efficient use of spectrum, to that of Teledesic. As noted above, Teledesic's optimistic *stated* capacity is 2 million simultaneous 16 kb/s users. Given the LMDS design for data services established in the NRMC, LMDS could provide this same capacity in the same spectrum using only 80 LMDS cells, which is equivalent to the size of an LMDS deployment in a single large metropolitan area (about 2300 square miles). Then, with LMDS, the same spectrum can be reused at virtually any point on the surface of the earth, while Teledesic cannot reuse the spectrum *anywhere* on the earth.

The comparison of Teledesic and LMDS capacity is also striking when the New York PMSA is considered, which is the operating market for CellularVision of New York. The New York PMSA covers 1,147 square miles with a population of 8.6 million and about 3.5 million households. The Teledesic "cell" is 53 by 53 kilometers, or 1,085 square miles--roughly equivalent to the New York PMSA. Shockingly, the Teledesic system can handle only 14 simultaneous T1 service links *to cover this entire area and population*, while CVNY, upon initial deployment of a full system for New York, could provide nearly 26,000 T1 service links. In this one instance alone, CVNY can provide nearly *two thousand times* the capacity of Teledesic! As demand for the service grows beyond 26,000 T1 lines in New York, the capacity of the CVNY system can be upgraded to support a service level *five thousand times* the capacity of Teledesic in New York.

Low Teledesic Capacity is Positive for Co-Frequency Sharing

A combined view of the Teledesic capacity and its impact on sharing is also compelling. Given the surface area of the earth, Teledesic's system coverage plans, and the approximation that the earth is two-thirds (unpopulated) water, Teledesic is projected to have about 58,000 "earth fixed cells" over land (each 53 by 53 km). Given the *stated* system capacity of 2 million simultaneous 16 kb/s service links, this would amount to an average cell capacity of 35 simultaneous 16 kb/s service links, or approximately 0.35 T1 service links. Teledesic has stated that some cells may generate traffic at a rate of 100 times the average cell (NRMC-24), which means that the "peak" cell would involve 35 T1 service links. Unfortunately, Teledesic's single-cell capacity limits the number of T1 per cell to *only fourteen* (NRMC-24). Additionally, note that the Teledesic cell is approximately equal in size to 38 LMDS cells, so the "peak" Teledesic cell would produce a density of approximately about 0.37 T1 service links per LMDS cell. That same LMDS cell could accommodate more than 660 T1 service links! Teledesic has made much noise about the concept of coexisting, "ubiquitous" Teledesic and LMDS. This issue is addressed elsewhere in this paper. But Teledesic's own design for "peak" cells clearly shows that only 0.37 of a single T1 Teledesic service link per LMDS cell is to be expected. Mitigation of interference from this single earth station into LMDS should not prove to be an insurmountable challenge using the very interference mitigation techniques offered by Teledesic in its application to the Commission. Teledesic chooses to ignore these facts which are a result of its own self-limiting design.

It should be noted that, if Teledesic chooses to deploy terminals at the "peak" density in the interest of flexibility, doing so would result in reduced capacity to serve cells with below average density since the overall system capacity is fixed. For example, of the approximate 58,000 Teledesic cells over land areas on the Earth surface, for every cell in which the maximum of 14 simultaneous T1 service links are operated, about forty cells, or an area of more than 43,000 square miles would be deprived of Teledesic service. This is a consequence of the overall Teledesic system capacity, and is telling as regards Teledesic's true intentions to serve the "have nots" heralded in its application–Teledesic wants to reserve the ability to serve dense areas in which more cost effective service options are available and in doing so deprives service to 40 times as many cell areas in which there may be no service options. Teledesic cannot "have it both ways" because of its limited system capacity.

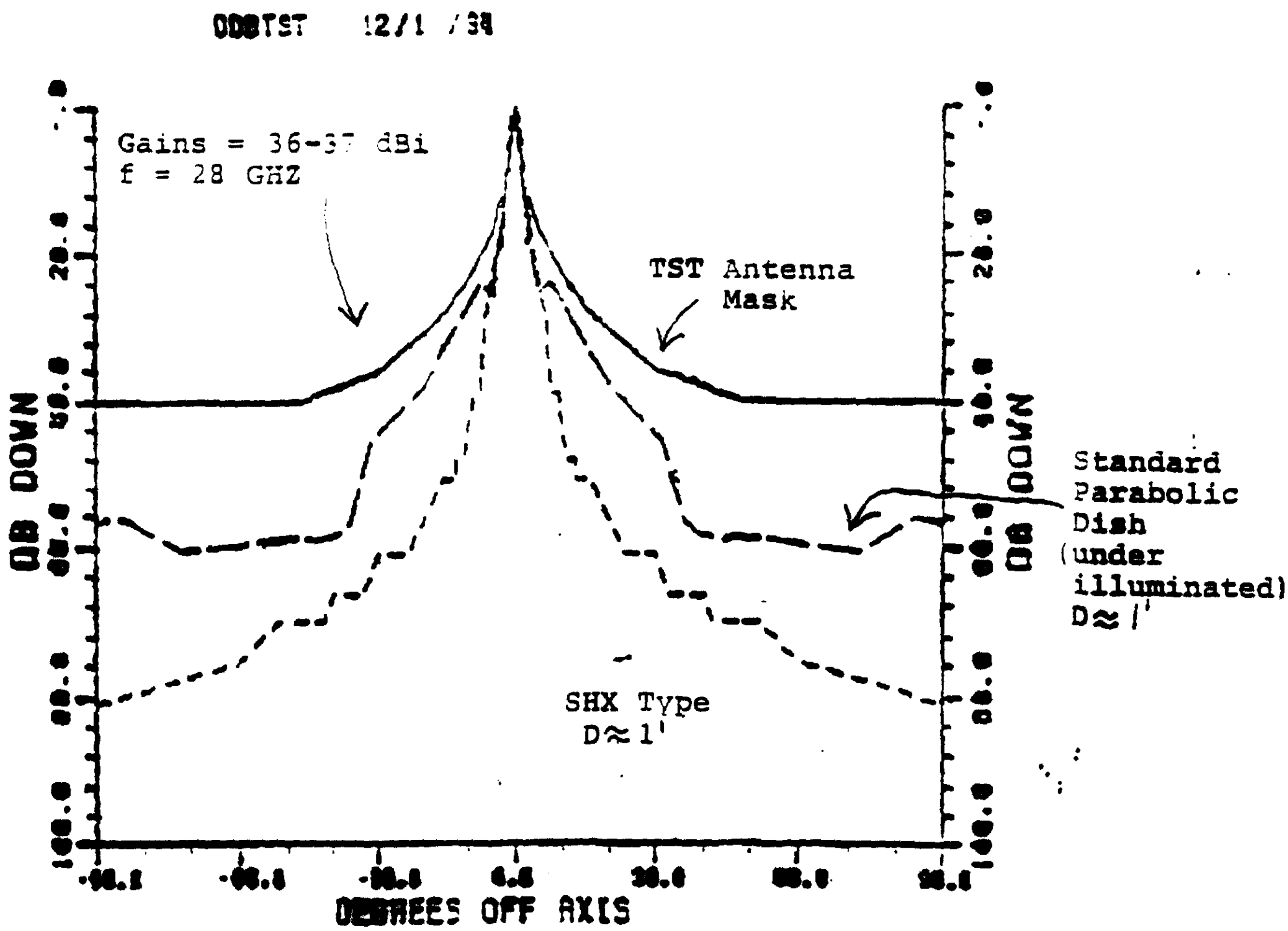
Still another way of looking at the impact of the limited capacity of the Teledesic system on a per-cell and overall basis is to note that if Teledesic insists on serving cells at their maximum capacity of 14 T1 service links per cell, then only 1429 of the approximate total of 176,000 earth-fixed cells in the Teledesic system can be served. This is only 0.81 percent of the earth surface area!! The rest of the earth, or 99.19 percent of the earth, is "out of luck." LMDS, on the other hand can offer reuse of the spectrum the world over.

Conclusions

In conclusion, Teledesic, while refusing to consider system design considerations which will have no impact on the capacity of its system (and hence revenue potential), is holding out for the survival of a system design which is both wasteful of the precious public spectrum resource and disastrous as a business prospect. The "ubiquitous" deployment of Teledesic service over the world will offer an insignificantly small improvement in access to the "information superhighway." Teledesic's refusal to entertain practical sharing spectrum sharing options, proposed by Teledesic itself in its application to the Commission, is rooted firmly in its insistence in maintaining the flexibility to operate in LMDS service areas with terminal densities far greater than would be expected in any rational market analysis given more cost effective alternatives. CVNY, on the other hand, is actively and positively pursuing combinations of interference mitigation, deployment planning, and band sharing approaches to maximize the potential of the limited spectrum.

The antenna sidelobe improvements proposed by CVNY for use in maximizing sharing potential are consistent with *today's* technology. Exploitation of this current technology in systems proposed for sharing the 28 GHz band, along with the Teledesic system's inherent capacity self-limitations, will allow coexistence of FSS and LMDS. Co-existence is a moot point if the Teledesic system, which is extremely risky from a technical and financial point of view, is never deployed. With the availability of financially-attractive, broadband telecommunication alternatives such as CVNY's LMDS, Teledesic is not likely to progress beyond the concept stage.

Attachment A



Sidelobe Suppression of Andrew Antennas Compared With TST Antenna Mark

Intra-system Interference in the Teledesic Satellite Uplink

1. Teledesic VSAT interfering with digital LMDS

The simulation performed by Teledesic and documented in JTSG 4.4B has clearly shown very severe degradation between two *frequency coherent and symbol timing coherent phase shift keyed signals*. The emphasis here is on the coherence of these two crucial parameters. The Suite 12 system is *not* synchronous with Teledesic, since the systems run autonomously from each other. The Suite 12 hubs have their own internal reference temperature controlled crystal oscillators, these are not even planned to be synchronous among themselves, although it is implied that the VSATs of the Teledesic system are synchronized to the satellites' own central reference clock (see Figure 2-5 of WG2/2). This being the case, the interpretation of the simulation results obtained bear no significance on the interference analysis between Suite 12 and Teledesic.

But the result is interesting and raises a question if there is a system vulnerable to *this* kind of jamming. In our opinion there is, and if we analyze the issue a little further the result, in fact, highlights the vulnerability of the Teledesic system as is currently proposed to ***self-jamming***.

To understand the reason behind this phenomenon we have to review some pertinent aspects of Teledesic. Each satellite is equipped with 64 simultaneous antennas and receivers. The front end receivers have 400 MHz instantaneous band width. Each beam spirals over nine 53.3 km x 53.3 km cells with a 2.276 msec dwell time per cell. There can be 1440 VSATs in a single cell, transmitting on any of 1440 FDMA channels in the 400 MHz band width at an information data rate of 16+2 = 18 kbits/sec per FDMA channel. On any given frequency, though, there can be at the most 64 space division multiplexed uplinks beamed at the satellite at any given time.

The satellite antenna beam has a side lobe rejection of -30 dB. Assuming for simplicity that all beams arrive to the satellite with equal power - there could be a few tenths of a dB variation from cell to cell due to the variability of slant range - *63 equal power interfering beams* from the other cells operating simultaneously increase the interference flux by 18 dB. Half of these beams are polarized in the opposite direction, but as it was discussed during the Working Group with the help of Mr. Engle (JTSG/3), it was concluded that the side lobes of a circularly polarized antenna are notoriously difficult to control and may have wide range of axial ratios. The Working Group agreed that *effective* polarization isolation is no more than 3 dB, thus only the antenna side lobes will attenuate the uplink *interference* on the aggregate by 30 + 3 dB relative to the main beam. The result is an interference flux at the antenna that is 18 - 33 = - 15 dB below the desired signal density. This is equivalent to a *C/I = 15* dB. The specified C/I was *25* dB in the document JTSG/9 WG2/3 Rev.1, August 9, 1994. Thus, it appears that the operating C/I is 10 dB less than the presented one at 100% utilization of a single uplink frequency - a 64-fold space division frequency reuse.

It is interesting to consider less than 100% utilization of a single RF channel, for example a 10 % uplink utilization. This utilization factor will, on the average, achieve the specified carrier to interference ratio, i.e., C/I = 25 dB.

The first impression one gets is that the specification does not allow any other satellite or terrestrial system to co-exist with Teledesic.

The second point is: based on the digital system to digital system analysis and simulation by Teledesic, as that system is configured today it cannot co-exist with its own VSATs, either. This is because these terminals are *frequency and symbol timing coherent*. Frequency coherence is needed to maintain the FDMA channelizing, but even more importantly, symbol timing coherence is mandatory in that system to allow for beam switching, inter-satellite links, and conversion from FDMA uplink to TDMA downlink via an on-board 400 MHz wide digital transmultiplexer, one for each beam. As the interfering signals arrive with a random carrier phase the amount of degradation any of them causes is random and its effect also varies from QPSK symbol to QPSK symbol.

A further complication is that during rain fade, while uplink power control is employed the Teledesic link margin is decreased by an additional 2 dB. It is conceivable that it rains uniformly over 1.6 million km^2 area fully covered by the 64 beams, but a much more likely scenario is selective fades over certain cells, in which case there will be an additional 2 dB increase in the interference immunity reduction.

2. Narrow band interference and wide band signals

The Teledesic uplink packets indeed can interfere with several wide band digital systems. The reason for that is the extremely high EIRP it generates in short bursts: 16.5 dBW for TSL and 49.3 dBW for GSL terminals. One can look at the Teledesic uplink FDMA/TDMA modulation format as a *period - 9* time hopping spread spectrum system. In fact, the 512 bits of information at a rate of 18 kbits/sec is transmitted in bursts of 2.276 msecs over a 275 kHz wide RF channel. The spreading gain is (512/18)/2.276 =28.444/2.276 = 12.5. It is well understood that this sort of signal, short and high power, can complicate proper receiver operation. That is the reason for its use as *pulse jammers* in military communications. Its effect can be mitigated by a more complicated receiver structure, employing finer quantization, adaptive pulse cancellation techniques, stronger error control codes, *&c.*

EXHIBIT C

THE WALL STREET JOURNAL.

MARKETPLACE

B6 THE WALL STREET JOURNAL TUESDAY, MARCH 22, 1994

INDUSTRY FOCUS

McCaw-Gates Satellite Plan Draws Skeptical Reviews

System of 840 'Birds' Is Called Too Costly and Needlessly Complicated

By JOHN J. KELLER
Staff Reporter of THE WALL STREET JOURNAL

NEW YORK – A brash plan by high-tech entrepreneurs Craig O. McCaw and William H. Gates to launch a $9 billion satellite network is being derided as the next Star Wars – as in the failed defense strategy, not the highly successful film trilogy.

Industry experts – and a few potential rivals, predictably – said the plan launched yesterday to operate a network of 840 satellites will have a hard time reaching altitude, despite the lofty successes of its two patrons.

Mr. McCaw's pioneering company McCaw Cellular Communications Inc. is now the world's largest wireless carrier. And Mr. Gates built Microsoft Corp. into the world's largest software maker. But their satellite plan to provide a variety of services to rural areas world-wide is sure to fly into technical, financial and political flak that hasn't been adequately addressed in their proposal to the Federal Communications Commission, industry experts contended.

"God save us, it's the stupidest damn thing I've ever heard of," said John Pike, director of the Federation of American Scientists' Space Policy Project. "Terrestrial telephone is much less expensive to implement, and who would use their system who could afford it?"

Howard Anderson of the Yankee Group added: "This is a midlife crisis for both" Mr. McCaw, 44 years old, and Mr. Gates, 38. "It ain't gonna work." If the two entrepreneurs were truly serious, he asserted, they would put up far more of their own money rather than seeking backers.

But executives at the McCaw-Gates venture express confidence that the various hurdles will be overcome. "Today, the cost of bringing modern communications to poor and remote areas is so high that many of the world's people can't participate in our global community," Mr. McCaw said in a prepared statement. His new effort, he maintained, will be "an opportunity to broaden this vision to include all of the world's citizens."

Indeed, the McCaw-Gates venture, known as Teledesic Corp., will have to entice numerous manufacturers and governments to back what would be an extraordinarily costly project. By the year 2001, Teledesic plans to have its network of 840 satellites circling the Earth in a low orbit, offering a broad array of interactive voice, data and video services at prices similar to conventional wired services.

Yet potential investors already have myriad other satellite suitors. Motorola Inc. is building support for its similar Iridium effort, a $3.4 billion launch aimed at mobile users. Loral Corp., the defense contractor, is teaming with tiny Qualcomm Corp. to launch its 48-satellite GlobalStar system. TRW Inc.'s Odyssey project is a smaller, 12-bird system in final development stages. And still another effort, Ellipsat, already has the support of Westinghouse Electric Corp., Harris Corp. and Fairchild Space Corp.

"We'll exploit rural telephone service before the others even get started," said Gerald Helman, a vice president at Ellipsat's holding company, Mobile Communications Holdings Inc.

> 'In the whole world, there are about 300 to 350 active satellites' now, far fewer than the number envisioned in the network, noted John Pike of the Federation of American Scientists.

Teledesic is far more ambitious, given its goal of putting 840 satellites aloft. Even if Messrs. McCaw and Gates can raise the money needed, however, they would need to lure millions of users to generate enough traffic to pay off the cost of the network, which will be at least three times more expensive than Motorola's elaborate Iridium satellite project. Rural folks and underdeveloped regions, the primary target of Teledesic marketers, aren't used to paying large sums for communications services.

Just launching that many birds will be an awesome undertaking, noted a spokeswoman at TRW. Assuming the launch of 840 satellites is successful, "there's an awful lot of ground control."

More ground control of satellites, in fact, than the North American Aerospace Defense Command, known as Norad, handles from its base in Colorado Springs, Colo., noted Mr. Pike. "In the whole world, there are about 300 to 350 active satellites," he added.

It is also hard to see how the Teledesic partnership will be able to compete with conventional phone networks, much of which will be efficient high-speed digital fiber-optic highways by the turn of the century. And where there isn't fiber, Motorola and Sweden's LM Ericsson are selling cellular radio networks to fill in the gaps. Motorola says it has already sold 120 such networks in China, for example.

Motorola already has a big jump with Iridium. While the network would be marketed primarily to high-paying mobile phone and data users, there is nothing in the service's plan that would prohibit Iridium from offering a fixed regular phone service to rural customers.

For now, Iridium and Teledesic don't regard each other as rivals. While Iridium, by terms of its FCC license, is a mobile service aimed at hand-held devices, Teledesic is aiming its beams at people at home or in a business.

"There are real distinctions," said Russell Daggatt, Teledesic's president. "We aim to deliver affordable broadband communication services to areas where there isn't wired services, and Iridium would deliver high-cost narrowband service to mobile customers."

There could be some overlap with Teledesic in developing countries, however. Iridium's spokesman noted that a state phone company in one of these countries, for example, could decide as a temporary measure to set up a portable kiosk to provide a global link to a village, but that would likely be an interim step to building a traditional phone infrastructure.

Still, rivals hope that there's room for one more player in the satellite game. Ellipsat's Mr. Helman says the McCaw-Gates entry helps to "validate the need for mobile and fixed satellite services," suc as Ellipsat's under $1 billion project.

Another rival, CellularVision of Ne York L.P., is setting up a wireless servic to deliver video programming to the home starting in Manhattan. The servic operates in the same 28-gigahertz fre quency that Teledesic wants to use. Whil the FCC is currently looking at whethe satellite systems will interfere with terres trial systems such as CellularVision. Shan Hovnanian, CellularVision's chief execu tive officer, says, "I think that there definitely room for everybody. . . . I thin what this does is that it shows another sig of overwhelming support for wireless i general."

Teledesic also may have an edge ove rivals in the data race. While Iridiu would transmit data to portable devices a as much as 2,400 bits per second, Teledesi is promising data transmission at million of bits per second, enough to send data file at high speed and even moving images.

A top Sony Corp. executive finds tha intriguing. "It's very appealing," sai Michael Schulhof, president and CEO o the company's Sony Corp. of America unit a major purveyor of programming and c the electronic devices that would make us of global networks. Just extending fiber optic cable to homes in California alon would cost an estimated $16 billion, h noted, "so $9 billion isn't an outrageou amount of money for a global telecommu nications network. . . . I'd be the firs subscriber."

But Messrs. McCaw and Gates need t find more owners for Teledesic. Today each owns slightly more than 30% of th partnership, on which they have spent "couple of million dollars," according to a McCaw spokesman. The remainder is hel by McCaw Cellular, at 28%, and Kinshi Ventures II, at 10%, a Los Angeles venture-capital fund run by Edward Tuck, wh founded the Magellan global-positionin satellite system.

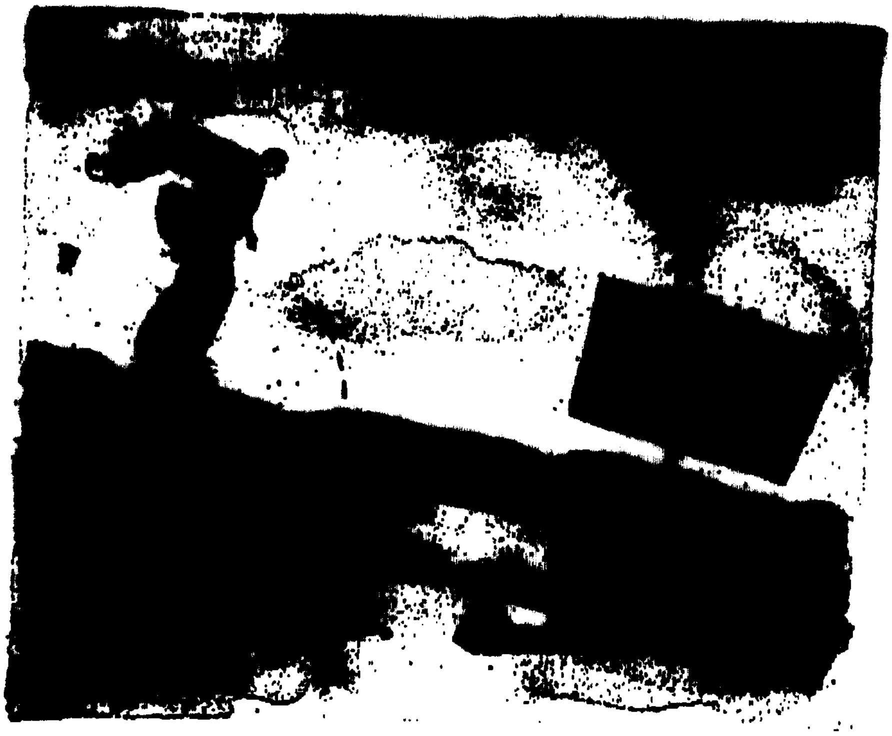
The McCaw Cellular holding would b transferred to American Telephone & Telegraph Co. once AT&T completes its expected $12.6 billion purchase of McCaw later this year.

–Don Clark in San Francisco contributed to this article.

EXHIBIT D

Global Ambitions

IT'S THE MOST AMBITIOUS project yet of the information age, and people would hoot if it weren't backed by Bill Gates of Microsoft and Craig McCaw of McCaw Cellular. The two billionaires' personal joint venture, the Teledesic Corporation, announced plans last March to blanket Earth with 840 communications satellites, far more than the total in orbit today. Teledesic's goal is to bring the information superhighway in all its glory to even the most remote reaches of the globe by the end of the century. "The basic concept is to create a system with the essential characteristics of an optical-fiber-based network," says Russell Daggatt, president of Teledesic, "but to provide service to areas that wouldn't be economical to wire." Some people hooted in spite of Gates and McCaw.



One reason for skepticism is the technical challenge: the project requires an entirely new type of satellite. Today's communications satellites occupy geostationary orbits 22,300 miles high—the precise altitude that enables them to orbit at the same speed as the Earth turns and thus hover above a single spot on the equator. While these distant satellites can carry a simple television signal, they can't handle such hefty freight as two-way video conferences or high-resolution medical images. Transmitting that much information requires a high-frequency, "broadband" signal—one that is more likely to get distorted by the atmosphere if you try to send it from, say, a northern city to a satellite over the equator. The long distance to the satellite also introduces a delay that can interfere with two-way data transmissions. For such transmissions you need a fiber-optic cable.

Or a satellite passing directly overhead in a low orbit. That's where Teledesic plans to put its 840 satellites: zooming along on 21 north-south orbits at an altitude of 435 miles. Since each region of the globe would have a satellite passing above it at all times, transmitters could aim more or less straight up, thus minimizing atmospheric distortion. "All you would need is a battery-powered station and an 18-inch antenna," says Daggatt. That would allow even the poorest countries to get connected.

Each satellite would weigh 1,700 pounds, with a flowerlike antenna spanning 40 feet, and could handle more than 20,000 simultaneous transmissions, each carrying 1.54 million bits of data per second. The satellites would have to be smart too. Unlike current satellites, which receive signals from one spot on Earth and bounce them back to another, each Teledesic satellite would talk to its neighbors, relaying a signal through space to the satellite that happened to be nearest the destination at that moment.

Nothing like it has ever been done before, so it's not clear the system will work. Each satellite, for instance, would have to be positioned very precisely. "The launch window would be less than one minute," says Neil Helm, a satellite-communications expert at George Washington University in Washington, D.C. "How often do we hear that a passing cloud or plane has extended a launch countdown? The Teledesic launches wouldn't have that freedom." And by the time the last of the 840 satellites are placed in orbit, the first could already be technologically obsolete. Daggatt says the satellites will be launched in rapid succession, stacked eight or more to a rocket.

Then there is the cost of building the system, which Teledesic estimates at $9 billion—a figure that puts the initial investment of $5 million each by McCaw and Gates into perspective. Even that figure, some say, is a gross underestimate: it assumes that Teledesic can mass-produce its satellites for around $5 million apiece. A conventional communications satellite now costs about $50 million.

Finally there is the political challenge. Teledesic needs the Federal Communications Commission's approval, which it applied for last March, to transmit its 20,000-megahertz signals. And it needs much more: it has to sell its idea for a global wireless Infobahn to the foreign governments and telecommunications companies that will be its main clients. Daggatt is already hard at work. "Even now most of the world doesn't have access to a basic telephone," he says. "If you look 30 or 50 years from now, the optical-fiber networks will be limited to the urban areas of the developed countries and maybe a few capital cities in the developing world. All the world that would not be economic to serve through fiber—that's the market we're seeking.

"With the pace of technological advances," he continues, "every day we're not pushing the state of the art as much as we thought we were. Sometimes we even wonder whether we're pushing it enough."

—Scott Faber

Exhibit E

Comparison of Telephone Service Capacity of LMDS and Teledesic System

by Bernard Bossard

As the following calculation shows, the telephone service capacity of the technically questionable Teledesic is extremely limited, compared to the United States' population. This calculation is based on the non-uniform distribution of population in the country. Approximately 90% of the U.S. population lives in about 10% of the land area, or about 300,000 square miles. A Teledesic cell is about 1,000 square miles in area. Thus, 300 Teledesic cells would cover the land area where 90% of the population lives. But each Teledesic cell has a maximum telephone call carrying capacity of 1400 calls. Therefore, the total call carrying capacity in the 300 cells is 300 x 1400, or 420,000 calls. But with a US population of 260 million, there are 90% of 260 million, or 234 million population in this area. The ratio of 420,000 divided by 234 million is 0.18%, which means that Teledesic can provide simultaneous service for only 0.18% of the population in this area. In contrast, LMDS can simultaneously serve 90% of the population, even in densely populated areas, because of its high degree of frequency reuse.

With respect to data communications service, the Teledesic capacity is even more constrained. Each Teledesic cell has a capacity of only 14 T1 data channels. Thus, in the land area occupied by 90% of the US population, this digital service can be supplied simultaneously to only 0.0018% of the population.

<u>EXHIBIT F</u>

U.S. SMALL BUSINESS ADMINISTRATION
WASHINGTON, D.C. 20416

OFFICE OF CHIEF COUNSEL FOR ADVOCACY

ORIGINAL

RECEIVED

MAR 2 8 1994

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)
	)
Rulemaking to Amend Part 1 and Part 21	) CC Docket No. 92-297
of the Commission's Rules to Redesignate	)
the 27.5-29.5 GHz Frequency Band and	) RM-7872; RM-7722
to Establish Rules and Policies for	)
Local Multipoint Distribution Service	)

Comments of the Chief Counsel for Advocacy of the United States Small Business Administration on the Second Notice of Proposed Rulemaking

---

Doris S. Freedman, Esq.
Acting Chief Counsel
Barry Pineles
Assistant Chief Counsel
Office of Advocacy
United States Small Business
Administration
Washington, DC 20416
(202) 205-6532

March 28, 1994

No. of Copies rec'd 0+4
List A B C D E

DOCKET FILE COPY ORIGINAL

RECEIVED

MAR 2 8 1994

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Rulemaking to Amend Part 1 and Part 21 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band and to Establish Rules and Policies for Local Multipoint Distribution Service	)	CC Docket No. 92-297 RM-7872; RM-7722

Comments of the Chief Counsel for Advocacy
of the United States Small Business Administration
on the Second Notice of Proposed Rulemaking

On February 11, 1994, the Federal Communications Commission (FCC or Commission) issued this second notice of proposed rulemaking. The Commission seeks comments on two issues: 1) whether a negotiated rulemaking should be conducted to resolve the technical issues associated with utilization of the 27.5-29.5 GHz band (28 GHz band); and 2) the benefits accruing from various uses of the 28 GHz band. The FCC believes that resolution of the technical concerns may lead to the implementation of significant new communication technologies.

The Office of Advocacy concurs in the Commission's conclusion that new uses of the 28 GHz band may be available in the near future. Many small businesses may wish to participate in the offering of these new services and resolution of technical issues through negotiated rulemaking will be important to these small businesses. Thus, the Office of Advocacy supports the use of negotiated rulemaking for the sole purpose of resolving technical issues.

While the resolution of technical issues is an important step in the allocation of the 28 GHz band, it is only a step. The Commission still must consider which services that use the 28 GHz band will best promote the public interest and goals of the Federal Communications Act.[1] The Office of Advocacy does not believe that the Commission should use negotiated rulemaking to determine the spectrum allocation that best serves the public interest. Rather, once technical issues have been addressed in the negotiated rulemaking, the Commission should use its normal notice and comment rulemaking process to allocate spectrum among various uses. The Office of Advocacy believes that a complete record in which the entire public has an equal voice in the rulemaking process will lead to the best allocation of spectrum. Furthermore, the Office of Advocacy believes that, when the record is developed, an allocation weighted towards terrestrial use will meet the primary statutory mission of the FCC -- making available rapid, efficient, and national communication services. 47 U.S.C. § 151.

[1] To the extent that the spectrum in the 28 GHz band is eligible for auctioning under Title VI of the 1993 Omnibus Budget Reconciliation Act, the Commission is required to provide a licensing scheme that gives small businesses the opportunity to provide service utilizing the 28 GHz band. No licensing regime can accommodate small businesses if the 28 GHz band is allocated entirely to satellite communication.

Currently, the 28 GHz band is assigned to satellite transmission technologies. However, technological breakthroughs have permitted terrestrial transmission within the 28 GHz band. The Commission has issued one full operating license and twelve experimental licenses for terrestrial uses of the 28 GHz band. Almost all of these licenses have been issued to small businesses. In contrast, all providers or potential providers of satellite service are large businesses or the National Aeronautics and Space Administration although some of the users of satellite transmission may be deemed small businesses.

Competing users, both satellite and terrestrial-based, may be able to share the 28 GHz band through such techniques as digital modulation. One of the primary unanswered questions in allocation of the 28 GHz band is whether terrestrial uses can coexist with satellite uses. The Office of Advocacy concurs with the FCC that the best method for resolving that issue is the use of a negotiated rulemaking. The parties involved can then offer their technical input and make direct inquiries of other parties about their data and engineering assumptions. The Office of Advocacy believes that negotiated rulemaking will lead to the most rapid resolution of technical issues surrounding the user of the 28 GHz band and avoid the current dispute associated with the award of pioneer preferences for personal communication services.

Resolution of these technical issues does not resolve the FCC's dilemma concerning spectrum allocation. In an ideal world, all of the users of a particular spectrum band could be accommodated. Scientific and engineering advances are gradually bringing communication technology closer to that ideal. Nevertheless, technology is not there yet and competing demands exist for use of the spectrum. The Commission then must decide the best method for utilizing the 28 GHz band. It may be that the negotiators will find that spectrum can be shared and multiple competing uses may be accommodated; or that only some competing uses may be excluded under a sharing arrangement; or that no sharing is possible under current technology. In any of these situations, the Commission still must decide on the appropriate allocation of uses for the 28 GHz band.

If satellite users and terrestrial users can coexist on the 28 GHz band, then Office of Advocacy has no objection to allowing all potential uses of the band. However, if coexistence is not possible, the Office of Advocacy supports an allocation that best benefits small business providers of telecommunication services.

Given the cost associated with the provision of satellite services,[2] the Office of Advocacy does not believe that small

---

[2] Two of the parties currently involved in the proceeding, Hughes and Suite 12, both want to use the 28 GHz band to provide a multichannel video delivery system. The ground-based system of Suite 12 is relatively inexpensive to develop while Hughes (continued...)

businesses will have an opportunity to participate in the provision of services if the Commission allocates the 28 GHz band to satellite users. In addition to increasing opportunities for small business providers of services, terrestrial uses also may provide greater benefits to small business users. Terrestrial-based services are local in nature and multichannel video providers can narrowcast, i.e., develop programming for specific population markets and advertisers.[3] Small businesses can use this narrowcasting feature to reach, at a reasonable cost, a large number of customers. Satellite services, both due to costs and their national reach, would not readily accommodate narrowcasting and its concomitant benefits to small business advertisers. Thus, the Office of Advocacy believes that substantial benefits exist in utilizing the 28 GHz for terrestrial services if coexistence is not possible.

Although the Office of Advocacy believes that terrestrial-based services will best promote the public interest, Commissioner Barrett is correct in seeking wide public comment on

---

[2](...continued) estimates that its satellite direct broadcasting service may cost approximately $500 million. Other potential satellite communication providers estimate system costs ranging from $660 million to $9 billion. Clearly, small businesses have no chance of participating as providers of satellite-based telecommunication services.

[3] Terrestrial uses of the 28 GHz band do not involve large geographic areas. Thus, a multichannel provider on the 28 GHz band can provide different programming for Chinatown in Manhattan and Little Odessa in Brooklyn.

the allocation of the 28 GHz band. Only in this manner will the FCC have the appropriate record needed to make an enlightened decision and accommodate the interests of all Americans in the use of a valuable public resource.

Respectfully submitted,

Doris S. Freedman
Acting Chief Counsel for Advocacy

EXHIBIT G